

Evaluating Three Different Methods of Determining Addition in Presbyopia

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Abstract

Purpose: To compare three different methods for determining addition in presbyopes.

Methods: The study included 81 subjects with presbyopia who aged 40-70 years. Reading addition values were measured using 3 approaches including the amplitude of accommodation (AA), dynamic retinoscopy (DR), and increasing plus lens (IPL).

Results: IPL overestimated reading addition relative to other methods. Mean near addition obtained by AA, DR and IPL were 1.31, 1.68 and 1.77, respectively. Our results showed that IPL method could provide 20/20 vision at near in the majority of presbyopic subjects (63.4%).

Conclusion: The results were approximately the same for 3 methods and provided comparable final addition; however, mean near additions were higher with increasing plus lens compared with the other two methods. In presbyopic individuals, increasing plus lens is recommended as the least time-consuming method with the range of ± 0.50 diopter at the 40 cm working distance.

Keywords: Amplitude of Accommodation; Dynamic Retinoscopy; Increasing Plus Lens; Presbyopia

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INTRODUCTION

Presbyopia as an aging alteration causes a gradual reduction in near vision^[1] which is initially noticed at the age of 40-45 years. The prevalence of presbyopia in population aged between 40 and 64 years has been estimated to be 58.15%.^[2] Presbyopia affects the performance of patients and also creates economic

burden if it is left untreated. The factors which can lead to presbyopia include a gradual reduction in zonular tension to increase lens power,^[3] gradually altered anterior segment geometry and increased lens thickness,^[1] changes in crystalline lens materials due to the aging process,^[4] and the accommodation mechanics by which the alteration in ciliary muscle position leads to flattening of crystalline lens decreasing its power.^[4] The initiation and progression depend on several factors including customary working distance, refractive errors, visual requirements, race, gender, geographic factors and environmental elements such as illumination and temperature.^[5] Age is the main risk factor in presbyopia; however, other factors such as trauma, cardiovascular

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diseases, systemic diseases (influenza, diabetes mellitus, multiple sclerosis, myasthenia gravis, anemia, etc.),^[4] drugs (antihistamines, chlorpromazine, antianxiety agents, antidepressants, antipsychotics, antispasmodics, diuretics, etc.),^[4] and environmental issues have been proposed to play a role in the development of presbyopia. Blur vision and disability to detect details in near tasking are the main presentations; however, headache, asthenopia, drowsiness, diplopia and an increased working distance are frequently complained by the patients as well.

The amplitude of accommodation is a unique measurement for each eye. Therefore it is necessary to provide the weakest and most proper addition measured for each eye separately, in order to establish a correlation between accommodation and convergence.^[6] Patient's habitual working distance is a fundamental factor to determine a precise and suitable correction. According to a classic rule for optical correction of presbyopia, patients should use up to half of their amplitude of accommodation.^[6] Calculation based on the amplitude of accommodation is more accurate compared with subjective refraction.^[7] Age-related near addition values have shown a difference compared with the amplitude of accommodation measurements due to inter-individual differences;^[8] however, some studies proved that age-expected addition might be more precise compared with ones estimated by the amplitude of accommodation.^[9] Several methods have been used to determine addition.^[9] Increasing plus lens (IPL), balanced range of accommodation (NRA/PRA), amplitude of accommodation (AA), crossed cylinder test, age-expected addition, dynamic retinoscopy and near douchrome subjective preference are the most commonly used methods for determining addition in presbyopia. Goss et al^[10] applied dynamic retinoscopy (DR) to determine the reading addition in presbyopia and showed that this method could provide the best near addition and comfort for non-presbyopes. Bittencourt et al^[6] compared four methods for determining addition: One-half amplitude accommodation with minus lenses; one-third accommodative demand with the positive lens; balanced range of accommodation with minus and positive lenses and crossed cylinder test with initial myopization. The results revealed that all methods estimated the comparable and almost similar near additions. In order to clear the discrepancy between different methods and find a precise technique of determined addition, we conducted this study to establish the level of agreement between the three methods including increasing plus lens, the amplitude of accommodation and dynamic retinoscopy.

METHODS

The study comprised of 81 healthy subjects with presbyopia who aged between 40 and 70 years.

The study protocol was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran and the signed consent forms were obtained from all participants. The exclusion criteria included anisometropia more than 1.00 diopter (D), any macular abnormalities, significant cataract, unilateral or bilateral aphakia and pseudophakia, and the history of diabetes mellitus. Demographic data including age and gender were obtained. Comprehensive ophthalmologic examination including subjective refraction, slit-lamp biomicroscopy, and funduscopy examination were performed for each subject. Each patient underwent three methods for addition determination including amplitude of accommodation, dynamic retinoscopy, and increasing plus lens. The order of the tests was determined randomly, and the measurements were compared.

In order to determine the addition using the amplitude of accommodation, the "push up" method was used. Subjects were instructed to wear distance best correction and focus on the 20/20 line of near Snellen chart – as suggested by Ostrin and Glasser^[11] – with the right eye while the left eye was occluded. Patients were instructed to focus on an optotype in near chart while it was moved closer until the letter could no longer clearly seen. The inverse of the final distance in meters was recorded as the subject's amplitude of accommodation. If the working distance (WD) was considered as 40 centimeters, the amount of addition was calculated as " $WD - 1/2 AA$ " where AA is the mean amplitude of accommodation between both eyes,^[9] and if the working distance was less than 40 centimeters, then addition value was calculated as " $WD - 2/3 AA$ ". The estimated plus lens was considered as a final addition. Since the push up method could simultaneously change both the accommodation and convergence demands, it should be performed monocularly.^[10] For those patients with difficulty at reading a near chart without any addition, the amplitude of accommodation could be measured through their current addition. Finally, the amount of addition should be subtracted from the result.^[4]

In dynamic retinoscopy, the best distance correction was placed before the eye and patient was instructed to keep fixating to the 20/20 line of a near chart which was presented at 40 cm. Compatible with the technique used by del Pilar Cacho et al^[12] we applied the line of 20/20 as the near target to determine addition in each method. Retinoscopy was performed at the same distance, inserting plus lenses in front of the eye until the neutral point was obtained. The dioptric estimation shows the difference between the accommodative stimulus and the accommodative response. The dioptric amount of a "with" motion is equal to the lag of accommodation. Normal values for monocular estimated method (MEM) lag is usually reported as 0 to 0.75 D;^[10] thus; we subtracted 0.5 D from the final result due to the lag of accommodation; then addition was determined.

In “increasing plus lens” method, the distance correction was placed before the eye and patients were asked to hold the near chart in the habitual working distance then the plus lens was increased with steps of 0.25 D until the clear vision was obtained. To determine the most appropriate addition for particular tasks, the patient was given an interested sample of near vision task.^[4]

Statistical Analysis

SPSS software version 16 (SPSS Corporation, Chicago, IL, USA) was used for statistical analysis and Pearson or Spearman correlation tests were applied based on normal or abnormal distribution of data, respectively. Repeated measures ANOVA was used to determine whether there are any significant differences between the means.

RESULTS

The study included 81 patients composing of 31 male and 50 female subjects with the mean age of 55.35 ± 9.01 years. The most prevalent complaint was near-work difficulty (46.9%). The frequency of refractive errors recorded as 84.1%, 11% and 3.7% for hyperopia, myopia, and emmetropia, respectively. Subtle opacities of the crystalline lens were detected in 41.6% of subjects. Mean near addition obtained by AA, DR and IPL were 1.31, 1.68 and 1.77 D, respectively, which in comparison with the means of addition determined by three methods using One-way ANOVA, showed a not clinically but statistically significant difference ($P = 0.000$). Interpreting the results of correlation showed that there was high correlation between three methods (AA vs. Dyn: $r = 0.904$ AA vs. IPL: $r = 0.84$ Dyn vs. IPL: $r = 0.917$) ($P < 0.05$). Our results showed that IPL in 63.4% of the cases could present the clear and comfortable vision at near. The comfortable vision was defined through the evaluation of fluency in patients’ text reading and also by asking them

about their vision. Figure 1 depicts the various powers of addition determined by each of the three methods.

DISCUSSION

Precise assessment and management of presbyopia is critical since significant functional deficits occur once the condition is left untreated. Under-corrected or uncorrected presbyopia can lead to considerable visual disability and have a negative influence on the quality of life.^[6] Near additions are usually refined according to the subject’s favorite in terms of image clarity and a comfortable working distance.^[13] In the current study, it was aimed to investigate the difference between the addition values determined by three methods. The results revealed that IPL could prepare an optimal vision and patients felt comfortable with near addition through the range of clear vision on the either side of reading distance. Maximum difference among three methods was reported as 0.5 D. Several factors related to the test characteristics and inter-individual differences such as visual requirements, habits, former prescription may contribute to these outcomes.^[13] Furthermore, patients with the same age may need different additions depending on the concurrent refractive errors.^[13] Reduced accommodation for near vision in hyperopes probably occurs by increased sympathetic inhibitory effects caused by an increased underlying parasympathetic tone, as suggested by the results on tonic accommodation.^[14] It is difficult to compare our results with those of other studies, due to the difference between methods and demographic characteristics. Depending upon our results, the average of addition determined by AA procedure was less than two other methods, which can be explained by “push-up method” using for measuring the amplitude of accommodation through which by moving the chart to the eye, the angular size of the image and accordingly the amplitude of accommodation increase. Momeni-Moghaddam et al also found that the push-up method provided higher accommodative amplitude as the consequence of a decrease in the target distance, an increase in the angular size of the retinal image and also an increase in the proximal stimulation.^[15] In contrast, Rutstein et al found that the amplitude determined by the retinoscopy method was 2.7 D greater than that of the push-up method.^[16] In addition, subjective measurements overestimate the real amount of amplitude of accommodation particularly in the presbyopic population, possibly because of the increased depth of focus due to smaller pupil diameter.^[11] The amplitude of accommodation provides a more precise suggestion of accommodative status of patients and range of clear vision,^[6] although “push-up” method is not always applicable, especially for patients with communication problems.^[17] Dynamic retinoscopy (DR), an alternative method, provides a rapid objective

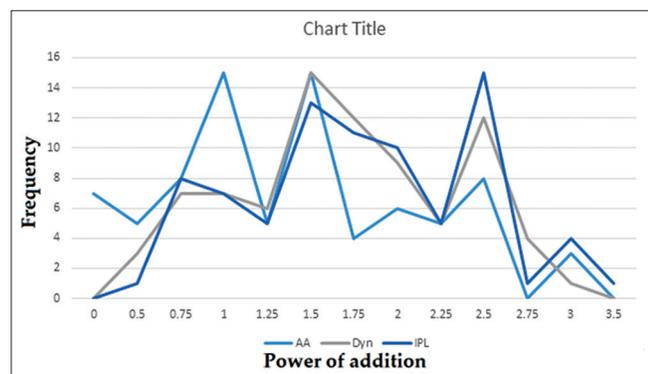


Figure 1. Various powers of addition by three different methods. Chart title: The frequency of different power of addition determined by each methods. AA, amplitude of accommodation; Dyn, dynamic retinoscopy; IPL, increasing plus lens.

Table 1. Mean of addition by different methods

Study	RGG (D)	CG (D)	AA (D)	AAL (D)	ADL (D)	BRA (D)	CCT (D)
Woo and Sivak ^[20]	1.30	1.50	1.30	-	-	-	-
Bittencourt et al ^[6]	-	-	-	1.92	1.80	1.78	1.94

RGG, red-green grid; CG, conventional grid; AA, amplitude of accommodation; AAL, one-half amplitude accommodation with minus lenses; ADL, one-third accommodative demand with positive lens; BRA, balanced range of accommodation with minus and positive lenses; CCT, crossed cylinder test with initial myopisation

measure of accommodation.^[17] However, it is associated with some sources of error such as patient fixation, media opacity and miosis of the pupil. Thus it can be a complicated and possibly unreliable method.

The results of our study showed that the amplitude of accommodation measured by dynamic retinoscopy was lower than the push up method which is in contrary with Rutstein et al's^[16] findings. The results of the current study showed that selecting a fast method is important in presbyopic subjects; IPL method can provide the best vision and patient's compliance. Antona et al^[9] compared final addition values with the tentative additions obtained using dynamic retinoscopy, the amplitude of accommodation, age expected addition, fused cross cylinder without initial myopization, fused cross cylinder with initial myopization, near duochrome and the negative relative accommodation/positive relative accommodation (NRA/PRA) balance. They concluded that the "age-expected addition method" provided the closest results to the final addition power, the narrowest agreement interval, and the least bias. However, in our study, the AA method provided the least power of addition and the IPL afforded the most comfortable vision. Hanlon et al^[18] compared four methods of determining near addition. They stated that binocular cross cylinder, NRA/PRA and AA measured by the push-up methods tended to overestimate the final addition, while the age-expected addition was comparable to definitive addition. Their findings show that AA method provides the minimum power of addition due to the increase in angular size of the image, which in contrary to our results. Whitefoot and Charman^[19] compared four methods of determining addition using dynamic retinoscopy with an amplitude of accommodation, duochrome test, and subjective preference. They concluded that the mean addition determined by dynamic retinoscopy was higher than one which was determined by amplitude of accommodation, which is in agreement with our results. Numerous methods have been used to determine reading addition, yielding different results [Table 1].^[6,18] Finally, most researchers suggest that tentative addition should be determined considering the particular needs of the patient.

In conclusion, there is a minor difference between three methods including amplitude of accommodation, dynamic retinoscopy and increasing plus lens used

in this study. Our findings indicate that amplitude of accommodation provides the least amount of addition and increasing plus lens gives the optimal and comfortable vision in presbyopia patients.

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Conflicts of Interest

There are no conflicts of interest.

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